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Round Table

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The Study of Growth and Its Meaning to Mankind

II. The Human Implications

An NBC Radio Discussion by

ROBERT J. HAVIGHURST, ANCEL KEYS
SHERWOOD L. WASHBURN *and* PAUL A. WEISS

Including

CAN THE WORLD PRODUCE THE FOOD IT NEEDS?

By SIR JAMES SCOTT WATSON

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From a Talk Presented by the British Broadcasting Corporation

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THE UNIVERSITY OF CHICAGO ROUND TABLE

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The Study of Growth and Its Meaning to Mankind

II. The Human Implications

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Mr. Weiss: Last week a group of us talked about the fundamentals of growth—the process which shapes all living beings and on which all life depends. We could do barely more than outline the immenseness of the problem and document the fact that we are on the right track to its deeper penetration and eventual solution. To get there requires the combined efforts of practically all the sciences. Benefits range all the way from securing our essential food supply to the repair of injury and the control of disease—with better understanding of life-processes in general in the bargain.

What specifically does increased knowledge of growth mean to man—to you and to me? How does it help us to adjust our lives and plan our future? What does it tell us about what we can or cannot hope to attain? If our young generation is taller than their elders, will their offspring do them one better and so on up, for centuries to come? Is our inheritance a strait jacket? How far can we stretch it by proper nutrition or other efforts?

To get our bearings in this maze of questions, we are fortunate to have with us on this Round Table three eminent men representing three different aspects of the field. In bringing four people from such diverse areas together, it seems we ought to ask ourselves: Do we have a common focus on which we can center? What does the study of growth mean to all of you?

Havighurst, you are an expert in child development and in aging problems. Would you like to make some comments as to what you hope to get from the study of growth?

Mr. Havighurst: Healthy children are growing children; and happy children are growing children. These things we know. We think of the job of the child as being to grow up, and thus we are very much interested in growth.

Mr. Weiss: Keys, your interest centers largely on heart disease and human health. What do you expect to gain from the study of growth?

Mr. Keys: People of different size and shape seem to have different tendencies toward disease. In connection with heart disease specifically,

body weight we know is of great importance. So, we must be concerned about this question of growth and the size of people.

MR. WEISS: And, Washburn, you have been most directly concerned with these problems as a student of anthropology and human growth in various races and experimentally. Can you tell us a little bit about what you gain from this?

MR. WASHBURN: We find that man grows according to the same general principles by which animals grow. Therefore, we have been very much interested to do experimental work on animals and to apply the results of these experiments to man, thus deepening our understanding of the process of human growth.

MR. WEISS: After having now described our common concern, let us take up some specific questions. Obviously there are people of all kinds of sizes. Looking around this table, we find people ranging all the way from five feet four to six feet four. Today we want to talk about this size problem.

Last week we came to the conclusion that the genetic constitution, the physical-chemical endowment of the germ cells from which we all develop, sets us a frame for our growth; but within that frame environmental influences have latitude to make for more or less growth.

I understand, judging from the sizes of medieval suits of armor, for instance, that the knights in those days must have been rather slight of stature. Is there a particular size trend in the human race, Washburn?

MR. WASHBURN: If we go back to the fossils of many thousands of years ago, we find big ones and little ones. The statures for Cro-Magnon man range from a little over five feet to around six feet—not too different from the sizes of the people now around this table. But in relatively recent time there seems to be a definite tendency to increase in stature. Several studies made at Smith College and at Harvard and at other places in Europe and even in Japan have shown a general tendency for fairly rapid increase in size in the last few years. So that the children tend to be taller than their parents.

MR. HAVIGHURST: Particularly have children increased their size. The difference seems to be much greater among children than among adults. For an example of this we might compare two studies of the sizes of fourteen-year-old boys of north European stock. One study was made in 1877; and another was made almost sixty years later in 1936. Between these two dates the fourteen-year-old boys had gained six inches in height. By this, I mean that a group of fourteen-year-old boys in

1877 compared with a group of fourteen-year-old boys in 1936 showed a gain of six inches in height and fourteen pounds in weight.

MR. WEISS: Has there been a change, for instance, when people move from one country to another country? Can you test that?

MR. WASHBURN: Yes, that has been tested. In general, when people move from one country and have better living conditions in another country, the statures of these people tend to be taller. However, one wants to be careful because there are racial differences. For example, the pygmies are exceedingly short people; and there is an example of a genetic limit. As Weiss mentioned earlier, the changes in environment only go to a certain point, and not beyond.

MR. WEISS: That is perhaps something which we ought now to discuss. Are there limitations to our size which are fixed and set in our constitution? How many of those changes which we have observed recently are due to changes in this composition, this initial constitution, and how much is due to better conditions of living, nutrition, factors of health, and so on?

MR. WASHBURN: Studies on identical twins show that, unless there is extreme disease or very great environmental difference, these twins even when they are living apart grow to almost exactly the same size; and this is a very good indication that there are genetic limits. This is perhaps the best control, genetic limit, that we know of in man.

MR. WEISS: You say exactly the same size. Are there not still differences possibly due to the environmental conditions even among identical twins?

MR. WASHBURN: Small differences. If one of the twins has been severely sick, these differences may amount to many pounds and some inches; but such differences between identical twins are very rare.

MR. WEISS: Do you think, Keys, the change then is due to perhaps nutritional conditions, to better nutrition?

MR. KEYS: I think that the difficulty with comparing peoples in different countries and the results of migration to other countries, as indicated in their sizes, is simply that many things change at the same time in the environment. When we look at the populations of all the countries which have been keeping records, the populations are getting bigger. That could be explained possibly in terms of nutrition. We also have to think of the decreasing incidence of disease and the tremedous change in social and living conditions in all the Western world in which we have these data.

MR. HAVIGHURST: Certainly the usual interpretation of the increase in height and weight of American children, as compared with two or three generations ago, has been that they have had better nutrition. For instance, they have probably drunk more milk since we have been able to pasteurize milk and make milk safer for children. Milk gives calcium and builds bones, and they have gotten cod-liver oil, which has vitamin D in it and which also is necessary to make bones. Would you say that this is an oversimple explanation?

MR. KEYS: Yes, I think that it is oversimplifying the question, because the diets in the different countries that we know about are quite different. The diets in Sweden and in the United States and in Italy, for example, are very different; and yet we see the same general tendency for each succeeding generation in modern times to get bigger in each of these countries.

MR. WASHBURN: Here we come back to our animal work, for we know that in our animals large strains can be due to genetic causes, or large animals can become large because of diet, and we know that disease will prevent animals from becoming large. So we see the same kinds of factors that we find in man.

MR. HAVIGHURST: Let me hold onto that point about the environment. I am pretty well convinced that the actual increase in size of men and women which has been observed in the industrialized countries in the last hundred years is due to some factor in the environment. Keys suggests that it may not be due to nutrition, because he says that not all countries have had the same kinds of change in nutrition. One other thing which we know has happened is that there has been a great decrease of infant mortality. That is, the number of children who die in the first year or two of life has decreased enormously. Maybe that might be related to this increase in stature, Keys.

MR. KEYS: Yes, indeed, if you think particularly of the large mortality which characterized all our countries in fairly recent times, that infant mortality could select out a particular kind of child and leave for survival children who would grow up to be a different size.

MR. HAVIGHURST: Then if this is a possible explanation, you would have to say that infant mortality has selected out the more rapidly growing children—the ones who otherwise would have been taller—and, therefore, the decrease of infant mortality has saved the lives of those children and thus given us an on-the-average taller race of people.

MR. KEYS: I think that there is other evidence that would indicate that might well be the case.

MR. WEISS: There is good biologic evidence that, the faster the system grows, the more susceptible it is to noxious agents—that is, harmful agents to the body, radiation and toxic agents, and so on.

MR. HAVIGHURST: Then it looks as though it is possible to grow too rapidly for the best health, perhaps for human beings as well as for animals.

MR. WEISS: Yes, there is definitely an optimum, and I hope that we come back to this point later in our discussion.

You are convinced then that most of the recent changes in height are due to environmental improvements.

I think that we still ought not lose sight of the main fact that we do not by all these improvements bring a small race up to the standards of height of a tall race—that on those differences the genetic limitation still exists. By those environmental conditions we only bring people more closely to the upper limit of that particular race. Is not that essentially true? There must be examples from Africa or elsewhere where people, small and large people, live side by side under similar conditions.

MR. WASHBURN: Yes, that is certainly true in Uganda, for example. The pygmies, the smallest men, most of whom are no more than four feet ten inches tall, and the Bantu Negroes, who are moderate-size people, and the Nilotic Negroes, who are among the very tallest people, all live within a few miles of one another in the same country. This certainly shows the genetic limitations on growth.

However, there are some dramatic cases where people apparently grew greatly due to environmental factors. For example, the people from England who went to Australia we think were very short people, and yet we regard the Australians as some of the tallest people in the world. This, I suspect, is largely an environmental factor.

MR. WEISS: But I think that in general, of course, the experience of man coincides with our general biological experience. There is a genetic limit to the size of a certain population, and environmental factors can only change the position of a particular individual within that frame.

So far we have considered only the question of height and stature. I think that that is an oversimplification. There are other factors which we ought to consider that go into the measurements of growth, about which we ought to be concerned now, such as our organs, our brain

muscles, and proportions of the body. Let us take the question of the brain up first. What about brain size?

MR. WASHBURN: It takes us about eighteen or twenty years to get full size in stature, but by the time we are three years old our brain is 80 per cent or even more of its adult size. The brain thus grows exceedingly rapidly, much more rapidly than most other parts of the body. It follows a very different pattern from stature, muscles, or bones.

MR. HAVIGHURST: Incidentally, you are talking here about the size of the brain and not the intelligence of the person, are you not?

MR. WASHBURN: That is right.

MR. HAVIGHURST: We know that the size of the brain has very little relationship to mental ability. People with big brains usually are people with big bodies, but there is no very close relationship between the size of the brain and mental development.

MR. KEYS: What about the question of the relationship between the size of organs, including the brain, and the extent to which they are used?

MR. WEISS: In the case of the brain, of course, the number of brain cells is definitely limited a few weeks after birth. There is no further addition. We have to go on what we have. But we now know, from recent observations, that brain cells individually can still grow or shrink with the amount of use to which they are put. However, we do not know whether this has any meaning for intelligence, so to speak. We only know that the physical size changes; whether it is relevant or not we do not know yet.

MR. HAVIGHURST: I would say that certainly as we think and as we do mental work something is happening to our brain cells, but those changes are, of course, so small that they do not show up at all when we talk about the gross body weight.

MR. KEYS: One difficulty about that is that we can be very busily engaged in thinking and not think very efficiently; and, therefore, intelligence and brain activity may not even be correlated very closely.

MR. WEISS: That is very true.

MR. KEYS: But I would like to come to the question of muscles, where we have a much simpler situation. The brain is in a bony box, and it cannot grow any more, anyway, in terms of total bulk; but the muscles certainly do change, up and down. What about that question, and what is the importance of that for our general discussion?

MR. HAVIGHURST: We usually think of boys and girls growing muscles. Boys particularly keep on growing them until early adulthood. What happens to muscle after a young man reaches his muscular peak, his physical peak?

MR. KEYS: The sad fact of the situation in the United States, it seems to me, is that after this peak is reached, after these youngsters finish their college age and stop playing football and things of that sort, their muscles diminish, and that diminution is very large. We see in our studies on young men and on middle-aged men a steady decline in the amount of muscle and the amount of living tissue, although the total mass of the body, the weight, tends to go up with advancing age.

MR. WASHBURN: I do not believe that that decline starts sooner at Chicago, even though we do not have a football team here, but I think that there is a close relation between the growth of the muscles and certain parts of the skeleton. We want to remember that the body is an organized whole, and we have been able to show in our experimental work that, as the muscles change in their size, parts of the bony skeleton also change exactly. Some of the changes which have been attributed to extreme old age in bone are probably due to the fact, as Keys has already mentioned, that the muscles in these older people have greatly decreased in size.

MR. HAVIGHURST: I take it that the reason muscles decrease in size is that they are not used and so become smaller. Does this suggest that the body quits growing then after the age of twenty-five or thirty?

MR. KEYS: It depends on what you mean by growth. The major change which occurs in the adult is the change in the proportion of fat in the body. We know, of course, that the young man at the age of twenty-five has his maximum muscle mass, but he actually weighs more at fifty than he did at twenty-five, and that difference is pure fat. So fat is the most variable component of the body.

MR. HAVIGHURST: Is that a good thing? After all, he does not need his muscle. Is it a good thing or a bad thing that he replaces muscle with fat as he becomes more sedentary?

MR. KEYS: The fat is useful in certain situations. If he fell out of a boat, he would float a little more readily with more fat in the body; but that is about the only use I can see for it, and we have evidence in the opposite direction that the fatter people certainly have a much poorer mortality experience than the thinner people.

MR. WASHBURN: If the man gains, let us say, about ten pounds be-

tween the ages of thirty and fifty, would this be a measure of all the fat he had gained in that time?

MR. KEYS: Our measurements on three hundred middle-aged men indicate that, while he is gaining ten pounds in gross weight, he is also losing about ten pounds in muscle and, therefore, he has a net gain of twenty pounds of pure fat.

MR. WASHBURN: Instead of the ten one would think from the weight difference?

MR. KEYS: That is right.

MR. WEISS: We have now really gotten into a discussion of what goes on inside the body. Without leaving any external trace in measurements, with the same amount we get a conversion of one tissue into another which is less useful, even harmful, as in the case of fat. That brings up not the problem of final size, which we have been talking about, but how we get there. Final size can be reached either by growing faster and for a shorter period of time or by growing more slowly and extending growth rates, the growth period, further. We ought thus to say a few words at least about the problem of growth rates, because they enter in our measurements of growth.

MR. WASHBURN: We do seem to be growing up much earlier than we used to. There is very good evidence that people grow up about four years earlier than they did a hundred years ago, and it has been thought that this is largely due to the environmental factor, which also perhaps affects stature, but we are not sure just what this environmental factor is.

MR. HAVIGHURST: By that you mean that boys and girls reach puberty, that is, pretty near the end of their physical growth, much earlier?

MR. WASHBURN: Much earlier.

MR. HAVIGHURST: You think as much as four years earlier than they did a hundred years ago?

MR. WASHBURN: The data are a little conflicting, but three to four years earlier seems to be a reasonable estimate.

MR. HAVIGHURST: Is there any evidence, for example, from the menarche, the beginning of menstruation on the part of girls?

MR. WASHBURN: Yes; there are very good records from England, and the change from 1850 to now is said to be four years at least, according to one study.

MR. KEYS: We do not have to go back a hundred years ago to see such differences. We see them today when we compare peoples in certain parts of the tropics with people here in the United States. We get a difference of that magnitude—four years, or thereabouts.

MR. HAVIGHURST: That is, the people in the tropics mature later?

MR. KEYS: Yes, in spite of the popular opinion to the contrary.

MR. WEISS: We have been talking about rates of growth, and, as we discussed last Sunday, the problem of growth is really a balance-sheet problem. There is always progressive production of organic mass, and there is at the same time a destruction of cells, of organic material. What we measure is really only the difference between the two. As the destructive process becomes more prominent, of course, we enter into a phase which becomes more conspicuous which we call aging, in which I think Havighurst is primarily interested. We all are interested too, because we are heading that way.

MR. HAVIGHURST: After the age of sixty, and perhaps even after the age of fifty for many people, weight begins to decrease, people begin to get smaller, and I think that it is proper to say that they are now growing in the negative direction. Of course, as Keys has said, for men after the age of about twenty-five or thirty the muscles begin to get smaller. So it would be proper, I would think, to think of the process of aging partly as one of growing in the negative direction.

MR. WEISS: Aging has not a sudden onset, but it really starts way back in development and only becomes more prominent as we go along, would you not say so?

MR. HAVIGHURST: Yes; it becomes evident, I think, to most people in the fifties. They do not like to think of themselves as aging until then, but then the physical evidences of aging become so evident that everybody accepts them.

What about the question of the value of being big or being small? We generally think of it being desirable to be tall and heavy, but Keys has made some suggestions that indicate that he doubts that. What about it, Keys?

MR. KEYS: It depends on what we are talking about. If we are talking about meat, whether it be animal meat or human meat, naturally we can measure the quantity and say that, if we are interested in quantity, more quantity is good; but the question in terms of human well-being and happiness is something else again. Throughout past history until fairly recently, we always faced the threat of insufficient

food and starvation. Therefore, we put a premium on the idea of having plenty of food and perhaps eating too much. This is one of our problems today.

MR. HAVIGHURST: You think that because of that kind of past history it is customary for people to boast about babies being fat and healthy?

MR. KEYS: I would say so. I think that it is a common experience that the pediatrician and the mother alike consider the well-being of the baby somehow or another to be measured in terms of pounds, and at the present time I am happy to see there is some question about that. People are beginning to wonder: Is that really the criterion that we are after?

MR. WEISS: Then, what is the criterion? What would be a proper criterion?

MR. KEYS: I think that we have to define more precisely the question. What is good depends on what you mean by good for. If we think of health, that is one thing; happiness would be something else—not necessarily the same.

MR. HAVIGHURST: I should say that for one thing a kind of growth which prolongs life, or at least which prolongs life until seventy-five or eighty, would be a good kind of growth, would you not?

MR. KEYS: Yes, if that life is lived under conditions of reasonable freedom from disease along the way. It has been said many times that one of the safest ways to keep living a long time is to have a mild disease all your life.

MR. WEISS: We have been talking about trends in human development in the past. We know that we have been breeding animals, either for small size or for big size, Pekingese as against Great Danes. Has the human race, for instance, been doing something of the kind? At different times was there a different emphasis on small size or large size perhaps? Do we have any evidence in our present world that there would be a premium on tall people or large people rather than small people, or vice versa?

MR. WASHBURN: In certain environments there seems to be a premium on very small size. For example, in the Congo forest the pygmies are the people who seem to get along best; and there has been selection perhaps here for very small stature. But, of course, with the industrial revolution and modern medicine, the situation in the world is rapidly changing, and we need standards which are adjusted to what is coming rather than to this long, remote past of man's history.

MR. KEYS: Man's accomplishment for many thousands of years was largely measured in terms of the amount of muscle power he could bring to bear on nature. That limitation and importance is no longer of any real consequence unless we are talking about football teams and matters of that kind, which are not necessarily the final criterion for human well-being.

MR. HAVIGHURST: It looks to me, then, as though we are fairly well agreed that the right kind of growth would produce people who are about the present average in height, that there is no great gain to having a much larger race of people; on the other hand, there is no great gain to having a much smaller race of people.

MR. KEYS: That would also have the advantage that we would not have to change the sizes of our furniture and houses and clothes and things of that kind. So there is some advantage in not changing too rapidly.

MR. WEISS: We have now come to the conclusion essentially that before we study where we want to go from here, medically and in public health, we not only have to know what goes into the process of growth but we have to get certain standards of our objectives—what we want to attain. We find bigger growth is not necessarily an advantage, in regard either to health or to occupation.

At the same time I think that we have come to the conclusion that, whatever we learn in the general study of growth in plants, animals, even from bacteria up, has its applications to the human formula, and, as in those others, we find that there is a limitation set by our genetic endowment of our potentialities. But within those potentialities we ought to strive to obtain the best possible solution, which means not necessarily the largest size.

CAN THE WORLD PRODUCE THE FOOD IT NEEDS?*

By SIR JAMES SCOTT WATSON

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I HAVE often thought how interesting it would be if we could get an independent view of our earthly problems from a group of intelligent observers who happened to be a few jumps ahead of us in science and philosophy. In the last million years they would have recorded advances and recessions of our polar ice caps, great dryings-up and dampings-down, with consequent effects on the distribution of our forests, grasslands, tundras, and deserts. They would have studied the dependence of the various forms of living organisms upon soil and climate and the one upon the other—plant in relation to soil and climate, herbivore on plant, carnivore on herbivore, parasite on host, and so forth.

The first time they recorded the appearance of a man on earth, they must have rated his chance of survival pretty low. He would have appeared to them as an offshoot from a rather unsuccessful group, the anthropoid apes—a slow-breeding species and therefore, from the genetic point of view, very slowly adaptable to change of environment. Poorly protected against cold, physiologically ill-adapted to bear high temperature, he would have been seen as unable to fly and a slow and awkward swimmer. He could not become a seasonal migrant like the swallow or the herring. Again, man's slowness of foot and his consequent inability to escape the larger predators, or himself to become a successful hunter, would have been only too obvious. Unable to live on grass, the most abundant of all foods, he would have been obliged to subsist on odds and ends—grass seeds, nuts and roots, insect grubs, molluscs, frogs, lizards, honey, and so forth. Supplies of such food being rather sparsely distributed, and being sought after by a number of more active species, a very large territory would have been needed to support even the smallest of human groups.

The view would have been inescapable at this stage that, as a

* From a talk originally presented on the Third Programme of the British Broadcasting Corporation and the first of a series of eight talks on the problem of "Research for Plenty" (see *The Listener*, August 7, 1952).

participant in the struggle for survival, man was destined to be one of the failures. Several species of ape-men had already petered out and *Homo sapiens,* for nine-tenths of his existence, had occupied a very obscure place in the world's fauna. Why, suddenly, did something happen—something very dramatic? Why were new and cataclysmic changes becoming progressively noticeable in the earth's environment, changes different in kind from those of former ages? It was because this single species, man, had developed will and memory and the power of speech. He began to make himself—potter, smith, farmer, and many things more. Unable to live on grass, he had turned the wild grasses into wheat, rice, and maize. In order that he might eat meat and drink milk, he had domesticated the herbivora, and himself, with tools of his own making, had eliminated their predators. To overcome his natural slowness of foot, he had tamed and was riding the wild horse and, finally, within the past two centuries (our own times, in fact), he had waged an increasingly successful war against his own parasites and diseases.

Thus far, the story would be one of sheer conquest. Man is seen no longer to fight for survival with the forces of brute nature. The forces seem to revolve round him, under his control. The numbers of his species have risen to some 25,000,000,000, and the marks of his cultivation show on the Arctic fringes of Canada and Russia and in deep cuttings into the tropical forests. Yet, to the outside observers, something bewildering seems to be happening now. A state appears to have been reached of complete ecological imbalance of the globe's flora and fauna. A projection of the current net reproduction rate of man implies a doubling and redoubling of his numbers at intervals of about two generations, while his food production is expanding at a lesser rate. In fact, it is too slow even to maintain human energy at a level which already, for many individuals, appears inadequate. Well might our outside observers begin now to speculate about the possibilities for ensuring man's survival—the likelihood of wars of extermination, like those previously noticed in primitive man's fights for hunting grounds; or planned control of the reproduction rate to restrict the numbers to be fed, using the same scientific methods as have controlled the rest of nature; or, again, a concerted effort to achieve a yet higher rate of progress in the processes of food production. It is this last approach—food production—that we are to explore in the present talks.

It has been said that our trouble has largely arisen from the unbalanced application of science; meaning that, in the past two centuries, the chief outcome of biological research has been the saving of human

lives, without any particular thought about the problem of feeding the survivors. Professor Ashby has remarked that our generation is the first to worry seriously about its great-grandchildren. There is a lot of worrying today. A dozen or more books have been written during these past few years, examining the question of whether, and if so how, our great-grandchildren can be fed.

Let me therefore mention some of the elementary facts, though they are quite generally known. Man, like other animals, needs a source of energy in order that he may work or move or even just keep alive. The necessary energy is produced by respiration—that is, the breakdown, in the body, of nutrients: sugar and starch, fat and protein. The energy is released partly as heat but partly also as chemical energy to support life and permit activity. In nature these nutrients are built up out of carbon dioxide, derived from the air, and water containing dissolved salts. The processing factory is the green plant, the catalyst is chlorophyll, and the source of energy is the light of the sun. But the efficiency of the green plant, as a conveyer of energy, is, at best, very low—of the order of two or three per cent.

Another fact is that some of the substances that are formed by the plant are useless as human nutrients. The wheat plant, for instance, stores less than half its energy in its grain, which we eat, and more than half in its straw. Straw is composed of cellulose, and man's digestive system is not designed to deal with that material. Moreover, a considerable amount of the cellulose is coated with lignin, and this prevents digestion even by the ruminant, which is equipped to make quite good use of cellulose as such: for instance, a cow can derive quite a large amount of energy from eating a cotton shirt or a sheet of blotting paper. But even the cow can make nothing of sawdust, because wood is heavily impregnated with lignin. Again, many human beings are not content with vegetable foods; they want at least a proportion of meat, milk, cheese, butter, and eggs. But animals are, in the nature of things, inefficient converters. A good hen or a good cow may yield up, in the form of eggs or milk, about a third of the energy of her food. The ox or the sheep yields, in the form of meat, only some ten per cent.

I am an agriculturalist; so let us now turn to the ways in which research can help to step up production under what we may call conventional systems of agriculture—using the land that is already producing food, the established crops like wheat and rice, potatoes and pasture grass, and the established types of livestock; cattle, sheep and goats, pigs and poultry. There is a constant and growing stream of useful dis-

coveries and inventions. Let me take a single crop, wheat, by way of illustration. A vast amount of work is being devoted to genetic improvement of the plant—to produce types that are increasingly resistant to the common diseases; that will stand up—literally stand up—to more intensive fertiliser treatment; will put more of their efforts into grain and less into straw; and will provide the kind of grain that can yield attractive and nutritious bread. That is a typical story—of a number of separate contributions to progress, some perhaps very slow and others perhaps small, but adding up, over a period of years, to a substantial total.

In other cases, developments follow each other at almost bewildering speed. For example, there are a fair number of dairy pastures in Britain that today are yielding twice as abundantly, in terms of bottles of milk per acre, as they did ten years ago. The result has been obtained by sowing better plant material, by more intensive use of fertilisers, and through a system of rationing the pasturage, by means of a movable fence, often electric, in order to ensure that the grass is consumed at the most nutritious stage of growth, while a minimum amount is soiled and trodden. Sometimes, again, the individual research worker makes a discovery with quite spectacular consequences. For instance, a good many areas of our uplands formerly failed to maintain normal health in the sheep that grazed them. The animals pined and the only traditional recourse was to move the flock to healthy land for frequent spells. Now the trouble can be avoided at the cost of administering, once in a while, a farthing's worth of cobalt.

Turning to the most important of farm animals, the three most serious diseases of dairy cattle are—or rather were—mastitis, contagious abortion, and tuberculosis. The first yields well to penicillin treatment; the second can be prevented by vaccination; and the third is in process of elimination by the application of a diagnostic test and the slaughter of the reactors. But despite an immense amount of patient, laborious, and brilliant research, there is still no better measure of control for foot-and-mouth disease than the slaughter of whole herds in which it has appeared.

Progress in food production would be faster if agriculture were organised like other modern industries—if it were conducted in large units under skilled management, with high-powered technical advice and specialised craftsmen, and with efficiency and financial gain as the predominant motives. In the advanced countries there are indeed many farms that approach this description. But at the other extreme are

many millions of small peasant holdings, where food production is only one of several activities, where the farm folk are illiterate, where age-old tradition is still almost the only guide, and where the material objective—often difficult to attain—is merely to provide a bare subsistence for the farm family. Moveover, the material objective is only one of many: for example, there is the maintenance of social prestige, the proper observance of religious rules, and the begetting of numerous children. It is easy to see that many a farming community is ill-organised for food production. The pasture land is in common, so that it is nobody's business to improve the grazing. The cultivated area is broken up into tiny and widely scattered bits and pieces, with an immense waste of both land and time; the marketing of produce is so ill-organised that there is little inducement to produce for sale; and the procurement of goods and services is equally ill-organised. All this is perhaps off our immediate point. But it is important to remember that much remains to be done, after the initial discovery or invention, before much in the way of increased production can be expected.

I am often asked: "Isn't it true that, up and down the world, and even in countries like our own, there is a great deal of land, now more or less waste, that could be turned into farms?" One specific question that I had recently was: "Couldn't we put a dam across the mouth of the Wash, and make another county, just as Holland is creating a new province out of what was the Zuider Zee?" The answer is that the floor of the Wash is worthless sand. All we can do is to wait for the silt to pile up along the foreshore and make intakes of a few hundred acres at a time. That process has been going on since the time of the Roman occupation. But could we not do more on our hillsides and our higher valleys? Something, no doubt. Perhaps squeeze out another 2,000,000 acres of moderate soil in a rather cold and wet climate, adding perhaps five per cent. to our farm area, but something substantially less to our productive resources.

What about other countries? Are there not deserts that could be irrigated, swamps that could be drained, forests that could be cleared? There are. And the work should be taken in hand; but the gain may be largely counterbalanced by items on the other side of the account—by the progress of erosion and the diversion of land to other purposes—mining, water supplies, building of houses and factories, and other competing uses.

But what about the vast expanse of tropical forest? A trying climate,